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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-103
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AD No.

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TESTING OF MORTAR SYSTEMS

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1. SCOPE.

This TOP describes procedures for determining the operational capabilities of mortar systems in a variety of environments, the effects of transport on mortar components, and human factors and maintenance concerns. Mortar systems characteristics dependent upon ammunition type, such as rate-of-fire tests, are also considered. Background information is presented in Appendix A.

Ammunition-specific tests, such as cook-off and blast overpressure and noise, have been eliminated from this document as they are better addressed under safety testing of mortar ammunition (TOP 4-2-504(3)**).

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*This TOP supersedes MTP 3-2-050 dated 18 June 1970.

**Superscript numbers/letter correspond to those in Appendix B.

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2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Item	Requirement
Firing range	Selected to suit test requirements and to provide adequate protection for personnel and equipment in event of ammunition and/or weapon failure.
Temperature conditioning chamber	To condition items to temperatures from 71 °C to -51 °C ±2 °C, with relative humidities ranging from 5% to 95%.
Environmental chambers	To maintain environments as required for adverse conditions testing.
Non-destructive test facilities (magnetic particle, X-ray)	To detect and evaluate surface or subsurface discontinuities (i.e., material soundness).
Vibration test facility (guidance in ITOP 1-2-601[1])	As required.
Rough-handling facilities (guidance in ITOP 4-2-602[2])	As required.
Test courses	As required.

2.2 Instrumentation.

Devices for Measuring:	Permissible Error of Measuring Device:
Projectile muzzle velocities (guidance in ITOP 4-2-805[b])	±0.1% or ±0.5 m/s (whichever is higher)
Weapon chamber pressure (guidance in ITOP 3-2-810[c])	±2%
Time of interior ballistic event (guidance in ITOP 3-2-810)	±3%
Test item temperature (guidance in TOP 1-1-058[d])	As required.
Physical characteristics of test item (guidance in MTP 3-2-801[e], ITOP 3-2-803[f])	As required.

Devices for Measuring:	Permissible Error of Measuring Device:
Meteorological conditions (guidance in TOP 3-1-003[5])	As required.
Test events (e.g., video tape, 35-mm camera)	As required.

3. REQUIRED TEST CONDITIONS.

3.1 Test Planning.

a. The tests as described in this TOP are used to determine safety, performance, and reliability characteristics of the weapon system in question. Plan the order of testing to allow the safety-evaluation tests (para 4.2.1) to be conducted first. Conduct high-risk tests which will reveal design weaknesses immediately following the safety tests.

b. Take care in planning the test sequence. Two or more subtests may be combined so long as no test criteria or objectives are jeopardized. Certain tests may be done concurrently, while other tests (such as sustained rate-of-fire and maximum operating temperature tests) can be done sequentially to take advantage of existing mortar temperatures to eliminate the need for expending additional rounds or using barrel heaters to raise the operating temperature of the mortar. Use inert projectiles and ammunition during firing tests if the use of such ammunition will not compromise test results.

c. The test procedures described herein may be required in a detailed test plan. The procedures may require modification for unique items or materials or to satisfy specific testing requirements as stated in the materiel developer's test plan or the Independent Evaluation Plan/Test Design Plan (IEP/TDP) or the Independent Assessment Plan (IAP).

3.2 Test Preparation.

3.2.1 Extreme Temperature Limits.

a. Unless otherwise specified, conduct mortar-system tests at a lower-extreme-temperature of -46 °C, which corresponds to the cold category C2 of NATO STANAG 2895[3] and MIL-STD-810E[4].

b. Conduct upper-extreme-temperature tests at 63 °C corresponding to the basic hot climatic category A2 of NATO STANAG 2895 and MIL-STD-810E.

c. Condition ammunition to be fired at either the upper or lower temperature extreme for a minimum of 24 hours.

3.2.2 Weapon Instrumentation.

Measure chamber pressure through the use of external piezoelectric or copper-crusher gauges. The use of such gauges requires a mortar tube tapped to receive the gauges. If such a tube cannot be obtained, use other methods, such as strain gauges or internal copper-crusher gauges to measure chamber pressure. Refer to ITOP 3-2-810.

Note: When employing external crusher gauges, it is important not to replace used gauges with new gauges until just before the next round is to be fired. Residual heat from the mortar may degrade the yield strength of the copper or aluminum gauge and thus skew the pressure readings recorded.

3.2.3 Arrival Inspection.

a. Visually inspect the equipment for signs of abnormal wear, rust, interference, and bright surfaces.

b Note special tools, accessories and protective covers supplied.

c. Conduct magnetic-particle or radiographic inspection on the mortar tube, basecap, and mount as described in TOP 3-2-807[h].

d. Record the following:

(1) Test-weapon type, model and serial number.

(2) Type of tube.

(3) Type of firing mechanism.

(4) Type of sight unit.

(5) Description of all accessories and tools supplied.

(6) Description of the physical condition of all mortar components, including faults detected by non-destructive test techniques.

(7) Presence of rust, burrs, abnormal wear, points of interference, and bright, reflective surfaces.

(8) Adequacy of any covers supplied to protect the equipment from the environment.

(9) Mortar-tube stargage data as described in MTP 3-2-801.

(10) Mortar-tube borescope data as described in ITOP 3-2-803.

(11) Length of firing-pin protrusion.

3.2.4 Physical Characteristics.

a. Determine the total weight of the test item and mount components.

b. Prepare the item for hand carrying as described in the appropriate field or technical manual and note the number, weights and description of loads into which the mortar unit can be disassembled.

c. Prepare the item for transport on either a towed cart or as part of a mortar carrier, and note the weight at each wheel, total weight, lunette reaction at pintle height, and height of lunette when reaction is zero.

d. Prepare the item for firing as described in the appropriate field manual.

e. Photograph the test item as set up in paragraphs b, c, and d above, paying particular attention to any unusual design features.

f. Determine types of rounds to be fired from mortar during test and all other compatible munitions.

3.2.5 Characteristic Data Sheet.

Prepare a Characteristics Data Sheet IAW TOP 3-2-500[5] consisting of a general-view photograph of the weapon and a listing of principal physical and performance characteristics.

4. TEST PROCEDURES.

4.1 Prefire Functioning and Alignment Tests.

Determine the smoothness of operation and physical aligrment of the major components and of the assembled test item as follows:

4.1.1 Mortar Tube.

4.1.1.1 Method.

a. Visually examine the interior condition of the tube and, when applicable, the threads on the breech end of the tube.

b. Determine the ease of alignment, assembly and disassembly of the individual mortar-tube sections.

c. Determine the need for quadrant seats on the tube or on the clamp.

4.1.1.2 Data required.

a. Interior condition of tube.

b. Ease of alignment, assembly and disassembly of tube sections.

c. Need for quadrant seats on the tube or the clamp.

4.1.2 Basecap - Fixed firing pin.

4.1.2.1 Method.

a. Remove the basecap from the tube.

b. Perform required measurements.

c. Replace basecap onto tube.

4.1.2.2 Data required.

a. Ease of disassembly of the basecap from the tube when not brazed.

b. Ease of replacement of firing pin.

c. Length of firing pin protrusion.

d. Concentricity of firing pin hole and basecap tube threads.

e. Ease of basecap assembly.

f. Conformance of component axes to specifications.

4.1.3 Basecap - Selectable firing mechanism.

4.1.3.1 Method.

a. Operate firing mechanism switch (and trigger, if applicable).

b. Disassemble firing mechanism.

c. Perform required measurements.

d. Reassemble firing mechanism.

4.1.3.2 Data required.

a. Method of functioning.

b. Ease of selecting the different types of firing.

c. Interference between firing lever and baseplate.

d. Ease of assembly and disassembly.

e Smoothness of operation.

f. Conformance to specifications.

4.1.4 Shock Absorbers.

4.1.4.1 Method.

Note: If the mortar has a recoil system, obtain the characteristics of the recoil portion of the mount as described in the applicable sections of TCP 3-2-815[1].

a. Manually exercise shock mechanism.

b. Disassemble shock absorber mechanism and inspect components.

c. Reassemble mechanism.

4.1.4.2 Data required.

a. Ease of assembly and disassembly of shock absorber mechanism.

b. Types and adequacy of lubricants.

c. Adequacy of moisture-proofing.

d. Adequacy of operation.

Note: Manually pull the shock absorber out of battery and allow it to return to in-battery position. If it fails to return or returns very slowly, check the alignment of the moving parts with their housing and verify the adequacy of provisions for the escape of trapped air.

4.1.5 Elevating and Traversing Mechanisms.

4.1.5.1 Method.

a. Elevate and traverse weapon through the entire range of movement using both coarse and fine adjustments.

b. Disassemble both mechanisms.

4.1.5.2 Data required.

a. Ease of assembly and disassembly.

b. Smoothness of gear operation in elevation and traverse.

c. Amount of gear backlash in both elevation and traverse.

d. Amount of handwheel effort required throughout the entire elevation and traverse.

e. Number of handwheel turns per degree of movement in elevation and in traverse.

f. Movement limits:

(1) Maximum and minimum elevation.

(2) Maximum and minimum traverse.

g. Safety hazards and inconveniences caused by handwheel location, taking into account the possibility of interference between the operator's hand and the tube support of the traverse yoke.

4.1.6 Mortar Clamp.

4.1.6.1 Method.

a. Unlock clamp and remove tube from constraint.

b. Reclamp tube.

4.1.6.2 Data required.

a. Ease of fastening and locking the clamp to the mortar.

b. Clamp slippage.

4.1.7 Cross-Leveling Mechanism.

4.1.7.1 Method. Use cross-leveling mechanism to remove induced-cant from weapon.

4.1.7.2 Data required.

a Smoothness of operation using the coarse and fine adjustments of the cross-leveling mechanism.

b. Ease of operation, determined while observing the level vial in the traverse yoke and checking the freedom of movement of the leveling mechanism when in the unclamped position.

c. Locking ability of clamp(s).

4.1.8 Telescopically-Adjusted Bipod Legs (if applicable).

4.1.8.1 Method. Adjust legs to minimum and maximum length.

4.1.8.2 Data required.

a. Freedom of movement.

b. Locking ability of clamps.

4.1.9 Bridge and Standard (if applicable).

4.1.9.1 Method.

a. Without moving the elevating and traversing mechanisms, shake tube and exercise recoil system.

b. Elevate and traverse mortar through range of movement.

4.1.9.2 Data required.

a. Fit of lugs with the trunnions in the bridge.

b. Ability of tube to return to original position after being temporarily displaced.

c. Operation of traversing and elevating mechanisms in the standard.

4.1.10 Baseplate.

4.1.10.1 Method.

a. Insert and remove tube from baseplate.

b. Determine adequacy of provisions for hand-carrying baseplate.

4.1.10.2 Data Required.

a. Fit of ball on mortar basecap into baseplate socket.

b. Ease of assembly and disassembly, if applicable.

c. Method of locking baseplate latches, if applicable.

d. Adequacy of carrying handles.

4.1.11 Sighting Equipment.

4.1.11.1 Method.

a. Affix sight unit (and/or boresight) to mortar.

b. Use sighting equipment to lay-in mortar.

4.1.11.2 Data required.

a. Ease of operation of sighting equipment.

b. Accuracy of sight-alignment (i.e., deviation from an established azimuth, compared with surveyor's transit).

c. Ease of alignment to the line of sight, checked with a mortar boresight.

d. Vial(s) adjustment ease.

e. Damage susceptibility.

f. Adequacy of the provision for stowing and carrying sighting equipment.

g. Adequacy of tools.

h. Adequacy of instructions.

i. Interference of sight controls with mount parts.

4.1.12 Mortar (Assembled).

4.1.12.1 Method.

a. Move the test item from the traveling position to the firing position and back to the traveling position; record data IAW 4.1.12.1 below. This task should be repeated three times with different test personnel.

b. Mark components subject to severe strain with trammel points or straightness lines.

c. Mount strain gages as described in TOP 3-1-006[j] or cover the surface of areas subject to strain with brittle lacquer as described in TOP 3-2-809[k].

4.1.12.2 Data required.

a. Time required to prepare weapon for firing.

b. Time required to prepare weapon for travel.

c. Difficulties encountered in preparation for firing and travel.

d. Number of personnel required to prepare the weapon for firing and travel.

e. Adequacy of instructions.

f. Adequacy of supplied tools.

g. Need for system-unique tools or whether common, off-the-shelf tools are adequate.

4.2 Ambient Temperature Firing Tests.

Note: Use inert-loaded projectiles and inert fuzes during the firing tests when the substitution will allow the test objectives to be accomplished.

4.2.1 Safety Evaluation Test.

The safety evaluation of a new weapon design requires the following tests to be conducted.

a. Proof firing of the weapon as described in paragraph 4.2.2.

b. Establishment of the maximum mortar temperature resulting from sustained fire, as described in paragraph 4.2.3.3.

c. Verification of weapon-system operational capability at maximum operating temperature as described in paragraph 4.2.4.

4.2.2 Proof-Firing Test.

4.2.2.1 Method.

Note: Proof-fire any mortar to be fired for test purposes to disclose any deficiency or malfunction that would preclude its further use. Under no circumstances shall it be used with personnel exposed until after proofing has been completed.

Perform proof-firing tests at prevailing ambient temperatures with the types and number of rounds specified in the materiel developer's test plan, IEP/TDP, or IAP. If a firing schedule was not provided, fire the rounds, in sequence, at the positions of elevation and traverse shown in Table 1.

TABLE 1. PROOF-FIRING SCHEDULE

No. of Rounds	Percent of Upper Pressure Limit*	Elevation (deg)	Traverse
Seating Rounds (approx 5)	50-75	60	Center
1	75	60	Center
1	100	45	Max right

TABLE 1 (CONT'D)

No. of Rounds	Percent of Upper Pressure Limit*	Elevation (deg)	Traverse
1	113 ± 4	45	Center
1	100	45	Max right
1	113 ± 4	60	Center

*The upper pressure limit (UPL) should be provided by the developer. When the UPL is not known, use pressure values for mortars of a similar construction as a starting point.

4.2.2.2 Data required.

a. Type and condition of soil under the baseplate in terms of moisture content and Cone-Penetrometer Index using a cone penetrometer in conjunction with a soil sampler and remolding test equipment as described in TB ENG 37 Soils Trafficability[1].

b. Number of rounds required to seat the baseplate.

c. For each round fired after the baseplate has been seated:

(1) Chamber pressure as described in ITOP 3-2-810.

(2) Muzzle velocities as described in ITOP 4-2-805.

(3) Length of out-of-battery movement of shock absorber.

(4) Change in elevation and traverse of mortar.

(5) Amount of muzzle smoke and flash.

d. Incurred strain as described in TOP 3-2-809.

e. During and at completion of proof firing, the following as applicable:

(1) Breaks, cracks (note welded portions), deformations, and binding of the working parts of the mortar and mount, photographing any failures.

(2) Interference between the operating parts at all possible positions of elevation and traverse.

(3) Ability of shock absorbers to return to the in-battery position at various positions of the collar and tube support.

(4) Gas leakage at juncture of mortar tubes and basecap.

(5) Gas leakage between firing pin and its contact surface in the basecap.

(6) Gas leakage at juncture of sectional tube.

(7) Slippage of mount collar on the mortar tube

(8) Slippage or turning of bipod legs or standard.

(9) Slippage of leveling mechanism.

(10) Possibility of firing without firing pin or with retracted firing pin.

(11) Ease of loading.

(12) Completeness of propellant burn within mortar tube.

(13) Ability of on-carriage fire-control equipment to remain locked in position during firing and to retain boresight alignment.

(14) Malfunctioning of ammunition (misfires and hangfires).

(15) Unusual occurrences affecting crew safety.

4.2.2.3 Post proof-firing inspection.

4.2.2.3.1 Method. Upon completion of the proof firing, perform the following:

a. Note effort required to turn handwheel.

b. Compare trammel-point positions on the mount with original positions.

c. Measure firing-pin protrusion and note any deformation.

d. Examine all moving parts and note evidence of wear or scoring.

e. Stargage the test item.

f. Borescope the test item.

g. Remove strain gages, if applicable.

h. Use appropriate non-destructive test technique (radiographic, magnaflux, etc.) to determine presence of cracks, deformations, etc., on mortar tube, basecap and baseplate.

4.2.2.3.2 Data required.

a. Stargage data.

b. Borescope data.

c. Effort required to turn handwheel.

d. Change in trammel-point positions relative to original position.

e. Firing-pin protrusion measurements.

f. Evidence of wear or scoring.

4.2.3 Rapid-Fire Tests.

Notes: Maximum physical rate of fire is described as the maximum rate at which it is physically possible to fire the weapon, limited by time and temperature constraints.
Sustained rate of fire is defined as the rate of fire, for a particular charge and ammunition type, at which the test weapon can be continuously fired without exceeding the barrel's designated maximum operating temperature (D-MOT).

4.2.3.1 Test preparation.

a. Adapt and install an electric timer to measure the time required for a projectile to slide down the tube and strike the bottom.

b. Affix thermocouples to points along the tube where maximum temperatures may be expected, or as directed in the test plan.

Note: Affix thermocouples to the tube so as not to alter the physical properties of the tube.

c. Place the test item on soil similar to the soil on which the proof firing was conducted and fire a minimum of five rounds to seat the test item.

4.2.3.2 Maximum rate-of-fire test.

4.2.3.2.1 Method.

a. Have one member of the test team fire the weapon at a specific elevation (minimum, intermediate, or maximum) using its maximum service charge, as fast as possible for a specified time period or until the tube temperature reaches the D-MOT.

b. Record data as indicated in paragraph 4.2.3.2.2 below.

c. Repeat this procedure a minimum of three times at each elevation, using different personnel for each repetition.

4.2.3.2.2 Data required.

a. Time of descent of the cartridge at minimum, intermediate, and maximum elevations.

b. For each team member at a specified elevation:

(1) Time required to fire each round.

(2) Number of rounds fired.

(3) Time to reach D-MOT.

(4) Maximum rate-of-fire (number of rounds fired/time to reach D-MOT). Expressed as number of rounds per minute for X minutes.

(5) Effects of blast, smoke, and flash on visibility, operation of fire-control equipment, and on firing team members.

4.2.3.3 Sustained-Rate-of-Fire Test.

4.2.3.3.1 Method.

a. Note temperature of tube, before firing, at all locations.

b. Heat the mortar tube with a barrel heater until a temperature approximately 30 °C below the D-MOT is reached. Immediately following this phase, remove the barrel heater and rapidly fire as many maximum-service-charge rounds as is necessary to bring the tube temperature to the D-MOT.

c. Alter the rate of fire so that the tube temperature is maintained constant at the D-MOT.

d. Note the rate of fire at which the tube temperature is stabilized at the D-MOT.

e. Repeat steps a through d for all applicable charges.

4.2.3.3.2 Data required.

a. Temperature of mortar tube at all instrumented locations.

b. Sustained rate of fire for all applicable charge levels.

4.2.4 Maximum Operating Temperature Test.

4.2.4.1 Method.

a. Heat the mortar tube with a barrel heater until a temperature approximately 30 °C below the D-MOT is reached. Immediately following this phase, remove the barrel heater and rapidly fire as many maximum service charge rounds as is necessary to bring the tube temperature to the D-MOT.

b. When the maximum operating temperature is reached, immediately fire 200 maximum-service-charge rounds (conditioned at 63 °C for 24 hours) at a rate which maintains the tube temperature at the D-MOT.

c. Note the time at which each round is fired.

d. After all firing has been completed, visually inspect the mortar system.

e. When the system has returned to ambient temperature, stargage the mortar tube. Test the tube, mount and baseplate for material soundness. Record operability of all mechanisms; note effort to turn handwheels.

4.2.4.2 Data required.

a. Tube temperature throughout firing and for 15 minutes following firing.

b. Time at which each round was fired.

c. Weapon-bore dimensions before and after firing.

d. Operability of all mechanisms, and the effort required to turn the handwheels.

e. Material-soundness-test results before and after firing.

4.2.5 Misfire Removal Test.

4.2.5.1 Method.

To determine whether additional safety procedures are necessary in removing misfires from the test mortar, have all gun crew members help to remove a simulated misfire from the test mortar. Accomplish the misfire removal while operating within safety regulations. Rotate positions of crew members until each has served in every position.

4.2.5.2 Data required.

a. Ease and safety of round removal.

b. Recommendations for modifying removal technique, if appropriate.

4.2.6 Pressure-Versus-Time Tests.

4.2.6.1 Method.

a. Modify a test mortar with pressure taps to receive appropriate pressure transducers IAW ITOP 3-2-810.

b. Temperature condition rounds for a minimum of 24 hours as indicated in Table 2 and fire immediately.

TABLE 2. CHARGES AND TEMPERATURES FOR PRESSURE-VERSUS-TIME TEST ROUNDS

No. of Rounds	Charge	Temperature, °C
3	Minimum	21, -46
3	Mean	21
3	Maximum Service	21, 63
3	Excess (113% ±4%)	21

4.2.6.2 Data required.

a. "As-fired" cartridge weights.

b. Muzzle velocities.

c. Peak chamber pressure.

d. Pressure versus time trace.

4.2.7 Stability-Firing and Seating Tests.

4.2.7.1 Method.

Note: If possible, repeat a stability phase for each set of test conditions; i.e., on the same day, repeat the firing of a test item from nearby ground of similar appearance. This repetition provides data for estimating the variation in stability that can be expected from the same baseplate under similar conditions. The magnitude of this variation is a good criterion for determining whether observed stability differences in baseplates are caused by differences in design or by the unavoidable variation in soil conditions.

Determine the stability of the mortar and baseplate and the ease of seating in both prepared and unprepared positions, as follows. Video-tape all firings for later review.

a. Determine and record the type of soil upon which the weapon is positioned as described in paragraph 4.2.2.2a.

b. With sandbags appropriately positioned on the baseplate, conduct the firing as shown in Table 3, re-laying the mortar after each single round and each group firing.

TABLE 3. STABILITY FIRING SCHEDULE

Number of Rounds	Elevation, deg	Traverse
Seating rounds (approximately 5)	60	Center
2 individual rounds and one 5-round group at each elevation/traverse combination shown.	Maximum	Center
	Maximum	Max left
	Maximum	Max right
	60	Center
	60	Max left
	60	Max right
	Minimum	Center
	Minimum	Max left
	Minimum	Max right

Note: All rounds are fired at maximum service charge.

c. Record data as directed in paragraph 4.2.7.2g below.

d. Repeat steps a and b without using sandbags.

e. Repeat steps a through c without relaying the weapon.

f. Repeat steps a through d with the weapon on:

(1) Sand.

(2) Mud.

(3) Very-hard ground.

g. Repeat all steps with weapon in an unprepared position.

4.2.7.2 Data required.

a. Type of soil.

b. Seating adequacy on unprepared soil.

c. The necessity for field expedients.

d. Preparations made to the positions.

e. Number of rounds required for each seating.

f. Comments as to the ease or difficulty experienced in seating the weapon.

g. After the baseplate is firmly seated, record the following for each round or group of rounds fired.

(1) Change in elevation and deflection.

(2) Number of centimeters the baseplate:

(a) Moved downward.

(b) Moved to the rear.

(c) Tilted side-to-side and front-to-rear.

4.2.8 Hard Surface Firing Tests.

4.2.8.1 Method.

Note: This test gives an indication of how the system may perform when fired from ice and snow surfaces.

a. Position the test weapon on a macadam or concrete surface without field expedients and conduct the firing as shown in Table 4. Record the type of surface used.

TABLE 4. HARD SURFACE FIRING SEQUENCE

No. of Rounds	Elevation, deg	Traverse
Seating rounds (approximately 5)	60	Center
5	Maximum	Max left
5	Maximum	Max right
5	60	Max left
5	60	Max right
5	Minimum	Max left
5	Minimum	Max right
5	Minimum	Center

Note: All rounds are fired at maximum service charge.

b. Examine the mortar after each round and record data as directed in paragraph 4.2.8.2 below.

c. Photograph or film any defects or hazardous occurrences.

d. Repeat steps a through c using field expedients.

e. Repeat steps a through d with the weapon on a rocky surface.

4.2.8.2 Data required.

a. Location of any breaks, cracks, etc.

b. Component failures.

c. Ability of mortar to seat and remain seated.

d. Incidents that may affect crew safety.

4.2.9 Accuracy Firings.

4.2.9.1 Method.

Notes: Weapon accuracy or system accuracy can be determined. Determine weapon accuracy by use of the gunner's quadrant for elevation and the surveyor's transit for azimuth; determine system accuracy by using the system sight unit for mortar laying.
Standard ammunition should be used for this test. If developmental ammunition is used, it's contribution to system error will be unknown unless groups from several lots are fired.

Determine the test item accuracy, using criteria as specified in the materiel developer's test plan, IEP/TDP, or IAP, as follows:

a. Firmly seat the test item and record the soil type.

b. Measure and record the meteorological data, as required in paragraph 4.2.9.2, on an hourly basis throughout the test period.

Notes: Commence measurements just prior to the start of the test firing.
Take measurements at ground level at the location of the test item and at the anticipated point of impact.
Take aloft data at intervals up to and including the maximum ordinate of the round to be fired.

c. Fire at least ten minimum charge rounds with the test item at zero traverse and minimum elevation.

Note: Return the test item to its prefiring position after each round is fired.

d. Repeat step c for each charge appropriate for the test item.

e. Repeat steps c and d with the test item at mean elevation and maximum elevation.

4.2.9.2 Data required.

a. On an hourly basis throughout the test period:

(1) Ambient temperature.

(2) Relative humidity.

(3) Atmospheric pressure.

(4) Wind speed and direction.

b. For each round fired:

(1) Muzzle velocity as described in ITOP 4-2-805.

(2) Time of flight as described in ITOP 4-2-805.

(3) Changes in elevation, if applicable.

(4) Changes in traverse, if applicable.

(5) Distance and direction the baseplate moved, if applicable.

c. Horizontal range and deflection of the impact of each fired round.

d. Maximum range recorded during firing at maximum-service-charge and minimum elevation.

e. Minimum range recorded during firing at charge zero and maximum elevation.

4.3 Adverse-Conditions Tests.

4.3.1 Preparation for Tests.

a. Clean the test item and apply a light coat of lubricant to the operating mechanisms.

b. Mount the test-item sight and accessories.

c. Cover the muzzle with the protective muzzle cover, if provided.

d. Note handwheel effort prior to subjecting test item to each adverse environment test.

4.3.2 Extreme Temperature Tests.

4.3.2.1 Method.

a. Using an appropriate climatic-conditioning chamber, set up the weapon system (including sight-unit) in the firing position and condition for 48 hours at -46 °C.

b. After conditioning, fire one maximum-service-charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

c. If no damage is found, repeat the process until ten maximum-service-charge rounds have been fired with the system allowed to return to -46 °C between rounds.

d. Immediately after firing, conduct material-soundness inspections of the weapon and components to determine the presence of cracks (TOP 3-2-807).

e. Photograph all defects.

f. Record handwheel efforts before and after firing at a specified mortar position for comparison with the effort noted during the prefiring check.

g. Examine the sight-unit for operability, including presence of moisture inside the telescope; note the operability of all sight knobs.

h. Repeat test with mortar conditioned for 48 hours at 63 °C.

4.3.2.2 Data required.

a. Interferences or malfunctions of mechanisms and moving parts induced by temperature extreme.

b. Functioning of firing mechanism (applicable if trigger or retracting-firing-pin components are used).

c. Positiveness of action of the firing mechanism.

d. Functioning of shock-absorber assembly.

e. Shock absorber's resistance to cracking at low temperatures.

f. Handwheel efforts.

g. Material-soundness-test results.

h. Operability of sight unit.

4.3.3 Sand-and-Dust Test.

4.3.3.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item to the blowing-dust conditions specified in MIL-STD-810E, Method 510.3.

c. After exposure, remove loose dust (sand) by shaking the test item, blowing on it, or wiping it with the bare hands.

d. Check visibility through the sight, and note presence of trapped dust.

e. Elevate and traverse weapon through complete range; note handwheel effort.

f. Note presence of any trapped dust (sand) in cannon bore.

g. Thoroughly clean weapon system and then repeat above procedures, exposing the weapon to the blowing-sand test of MIL-STD-810E, Method 510.3.

4.3.3.2 Data required.

a. Presence of dust in sight.

b. Operability of the lever-fire mechanism (if applicable) by firing in the lever-fire position and then in the drop-fire position.

c. Ease of lever-fire operation.

d. Handwheel effort required to elevate and traverse test item.

e. Amount of dust in cannon bore.

4.3.4 Icing Test.

4.3.4.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item and its components to the freezing-rain test as described in TOP 2-2-815[6].

c. After exposure:

(1) Check visibility through the sight, and note presence of trapped moisture within the sight.

(2) Attempt to elevate and traverse mortar.

(3) Fire one maximum-service-charge round (conditioned at 21 °C) and visually examine the weapon system for damage.

(4) If no damage is found repeat the process until five maximum-service-charge rounds have been fired from the weapon.

(5) Immediately after firing, conduct materiel soundness inspections of the weapon and components to determine the presence of cracks.

4.3.4.2 Data required.

a. Amount of ice needed to be removed in order to fire the first round.

b. Difficulty in elevating and traversing the test item.

c. Operability of the lever-fire mechanism by firing in the lever-fire position and then in the drop-fire position.

d. Ease of lever-fire operation.

e. Effectiveness of ice removal by firing.

4.3.5 Blowing Snow Test.

4.3.5.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item and its components, in a conditioning chamber to blowing snow having crystal sizes and winds as described in AR 70-38[m] for a period of 6 hours.

c. After exposure, remove the loose snow by shaking the test item, blowing on it, or wiping it.

d. Follow procedures as described in paragraph 4.3.4.1c above.

4.3.5.2 Data required. As shown in paragraph 4.3.4.2.

4.3.6 Mud Test.

4.3.6.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item to mud consisting of 10 parts red clay, two parts clean river sand, and enough water to permit the item to sink of its own weight.

c. After exposure, remove loose mud with bare hands.

d. Follow procedures as described in paragraph 4.3.3.1, sections c through e, examining the sights for mud.

4.3.6.2 Data required. As specified in paragraph 4.3.3.2.

4.3.7 Rain Test.

4.3.7.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item to the rain conditions described in MIL-STD-810E, Method 506.3.

c. After exposure, examine sights for moisture and evaluate the effects on the moving parts of the mortar.

4.3.7.2 Data required.

a. As specified in TOP 2-2-815 and MIL-STD-810E.

b. Presence of moisture in sights.

c. Presence of moisture in cannon bore.

d. Handwheel effort required to elevate and traverse weapon.

4.3.8 Humidity Test

4.3.8.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item to the applicable conditions as described in MIL-STD-810E, Method 507.3.

c. After exposure, examine sights for moisture, check for corrosion, and evaluate effects on the moving parts of the mortar.

4.3.8.2 Data required.

a. As specified in MIL-STD-810E.

b. As specified in paragraphs 4.3.7.2b through d.

4.3.9 Solar Radiation Test.

4.3.9.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item to five diurnal cycles of the hot-dry climate as described in ITOP 4-2-826[7].

c. After exposure, examine optical and moving parts for damage.

4.3.9.2 Data required. Damage to optical and moving parts.

4.3.10 Salt-Fog Test.

4.3.10.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item to salt-fog conditions described in MIL-STD-810E, Method 509.3 for 48 hours.

c. After exposure, examine the sights for moisture, check for corrosion, and check operability of all parts.

4.3.10.2 Data required.

a. Amount of moisture trapped within the sight.

b. Amount of corrosion.

c. Handwheel effort required to elevate and traverse weapon.

4.3.11 Water-Immersion Test.

4.3.11.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item or components to the water-immersion test described in MIL-STD-810E, Method 512.3.

c. After exposure, examine the sights for moisture and check the operability of all parts.

4.3.11.2 Data required.

As specified in paragraphs 4.3.7.2b through d.

4.3.12 Fungus Test.

4.3.12.1 Method.

a. Prepare the test item as described in paragraph 4.3.1.

b. Expose the test item to the conditions described in MIL-STD-810E, Method 508.4.

c. After exposure, examine all components for moisture, fungus, and corrosion.

4.3.12.2 Data required.

a. Presence of moisture, fungus and corrosion on weapon system.

b. Operability of sight unit.

c. Handwheel effort required to elevate and traverse weapon.

4.4 Rough-Handling and Transportation Tests.

The mortar shall be tested under the following conditions, as required.

4.4.1 Transportation-Vibration Test.

4.4.1.1 Method.

a. Package the test item as for shipment.

b. Conduct a simulated transportation-vibration test in accordance with ITOP 1-2-601 corresponding to a distance of 800 kilometers in a composite of wheeled vehicles and 50 kilometers in two-wheeled trailers.

c. Examine the test item and record the presence of any breakage, bending, loosening, or other damage.

d. When there is no obvious damage, test fire the item using a minimum of five maximum service charge rounds, then examine the test item and record any evidence of damage.

4.4.1.2 Data Required.

a. Transportation-vibration data as collected in ITOP 1-2-601.

b. Results of materiel inspections as conducted above.

4.4.2 Loose-Cargo Test.

4.4.2.1 Method.

a. Using an unpackaged test item, conduct a loose-cargo test in accordance with Appendix B of ITOP 4-2-602 to simulate 240 kilometers of loose-cargo transport over Belgian-block road.

b. Examine the test item and fire as described in steps c and d of paragraph 4.4.1.1.

4.4.2.2 Data required.

a. As collected in ITOP 4-2-602.

b. Results of materiel inspections as conducted above.

4.4.3 1.5-m Drop Test.

4.4.3.1 Method.

a. Using an unpackaged test item, conduct a 1.5-m drop test in accordance with Appendix C of ITOP 4-2-602.

b. Examine the test item and fire as described in steps c and d of paragraph 4.4.1.1.

4.4.3.2 Data required.

a. As collected in ITOP 1-2-601.

b. Results of materiel inspections as conducted above.

4.4.4 Air-Transportability Test. (To be used only if there are potentially damageable components.)

4.4.4.1 Method.

a. Using a packaged test item, simulate air transport at 15,200 meters in a stratosphere chamber for 3 hours, at an air temperature of -51 °C.

b. Examine the test item for damage.

4.4.4.2 Data required. Any damage to test item.

4.4.5 Air-drop Test.

4.4.5.1 Method.

a. Using a test item prepared for air-drop, conduct an air-drop test IAW the applicable sections of TOP 7-2-509[n].

b. Examine the test item and fire as described in steps c and d of paragraph 4.4.1.1.

4.4.5.2 Data required.

a. As collected in TOP 7-2-509.

b. Results of materiel inspections as conducted above.

4.4.6 Road Test.

4.4.6.1 Method.

a. For weapons transported in a trailer or transport vehicle, mount the item on the conveyance, establish trammel points and guidelines on the item and subject it to:

(1) 40 kilometers on the Belgian block course (APG).

(2) 80 kilometers on secondary roads.

(3) 160 kilometers on paved roads.

b. During the road tests, observe for deformations, cracks, and breaks.

c. After all road tests, completely disassemble the item and check all trammel points, guidelines, and bearing surfaces to determine wear and deformation.

4.4.6.2 Data required. As described in paragraphs 4.4.6.1b and 4.4.6.1c.

4.5 Post Firing Inspection.

4.5.1 Method.

a. Stargage the test item IAW MTP 3-2-801.

b. Borescope the test item IAW ITOP 3-2-803.

c. Measure the firing-pin protrusion.

d. Examine all trammel points and guidelines.

e. Examine all moving parts for evidence of wear.

Note: Some of the above inspections, in addition to being conducted at the conclusion of all testing, are conducted following an individual test phase when, in the judgment of the test director, such inspections are warranted.

4.5.2 Data required.

a. Stargage data.

b. Borescope data.

c. Firing-pin protrusion.

d. Deformations of firing pin.

e. For trammel points and guidelines:

(1) Wear of bearing surfaces.

(2) Deformation of bearing surfaces.

4.6 Human Factors Engineering Demonstration.

4.6.1 Method.

During the conduct of all testing phases (use guidance in ITOP 1-2-601 and TECOM Pam 602-1[8]), evaluate the mortar system to determine if it meets the operational and design requirements of MIL-STD-1472D[9] and MIL-HDBK-759[9].

4.6.2 Data required.

a. A record of the physical characteristics of the weapon and ammunition as they affect operation.

b. Notes on the adequacy and size of knobs, handwheels, and leveling devices on the weapon and sight unit; ability to operate these knobs/devices both with and without arctic/NBC handwear.

c. The times required to emplace the weapon and prepare to fire.

d. A notation of any features of the test mortar that are not compatible with the skills and aptitudes of MOS-qualified soldiers.

e. General ease of operation of the test item.

4.7 Tools-and-Accessories Evaluation.

4.7.1 Method.

Throughout the conduct of the test, examine all standard and special tools and accessories supplied with the test item. Use guidance in TECOM Suppl 1 to AMC Reg 70-15, Integrated Logistic Support[10].

4.7.2 Data required.

a. Suitability of the tools and accessories.

b. Requirement for additional tools.

c. Parts that are apt to require replacement, which should be included as spare parts.

d. Whether system-peculiar tools are, in fact, needed or if they can be replaced with common tools.

5. PRESENTATION OF DATA.

a. Present data in graphic or table format, as applicable, to summarize the results of each subtest performed.

b. Document the results of all post firing/test inspections and indicate the following:

(1) Effect of firing or transportation on the test-item alignment as indicated by trammel-point and reference-and-guideline measurements.

(2) Length of firing pin protrusion.

(3) Stargage measurements.

c. Calculate the mean and standard deviation for the following data.

(1) Time required to prepare the weapon for firing and travel (para 4.1.12).

(2) Time required to fire each round, time to reach the D MOT, number of rounds fired, maximum rate-of-fire (para 4.2.3.2).

(3) Muzzle velocity and chamber pressure (para 4.2.6).

(4) Range and deflection of rounds fired (para 4.2.9). Group data according to charge and elevation.

d. Present the change in weapon elevation and deflection and the distance in centimeters of baseplate movement (para 4.2.7) in tabular format. Group the data according to weapon orientation, surface fired from, and use of sandbags on baseplate. Indicate whether or not the weapon was relayed after firing.

e. Report malfunctions, operating difficulties and hazardous occurrences to the concerned technical agency as soon as practicable, using standard reporting methods such as Test Incident Reports (TIRs).

f. The safety information developed during the engineering test will be used as the basis for submitting a recommendation for Safety Release or Safety Confirmation to TECOM, IAW AR 385-16[11].

Recommended changes of this publication should be forwarded to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-CT-T, Aberdeen Proving Ground, MD 21005-5055. Technical information can be obtained from the preparing activity: Commander, U.S. Army Combat Systems Test Activity, ATTN: STECS-DA, Aberdeen Proving Ground, MD 21005-5059. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A. BACKGROUND

1. Introduction.

Weapon system safety and technical assessment are a continuous process. Initially, during early developmental tests, it is necessary to establish that the design is inherently sound. Later, it is necessary to develop formal test data to show that the weapon system is safe to use and is performing at a level which warrants continued production effort. If the item is type classified and production is initiated, it is essential to show that changes implemented to simplify production and the production process do not compromise the system's safety and performance. Finally, as product improvements are proposed for incorporation into the weapon system design, it must be shown that these improvements will result in a better system in terms of both performance and system safety.

2. Test Design Criteria.

Criteria for testing must be based primarily on the required operational capabilities, the IEP/TDP or IAP, and the test item and the procedures as outlined in this TOP. The following must also be considered:

a. Design review. Before undertaking the tests outlined in this TOP, the test director should perform a thorough review of all data related to the item being tested. These data can be obtained from previous related tests and/or design considerations. If the review shows that the test item conforms to a proven design and that its performance (or that of similar items) in earlier (engineering-design or component) tests are favorable, then the procedures as outlined in this TOP may be undertaken. If not, the test plan must be expanded to provide the necessary assurance.

b. Safety-assessment report (SAR).

(1) Submission of an SAR from the developer is required at least 60 days before the start of technical testing. The test director will review the sponsor's SAR IAW the Guide for the Development of Safety Assessment Reports and use or develop safe-operating procedure IAW AR 385-16.

(2) It is essential that the SAR contain the following information:

(a) Complete system description.

(b) Complete sequence of system operation emphasizing the safety features.

(c) Thorough misfire procedures.

(d) System hazard analysis.

(e) Acceptable ammunition for use.

(f) Weapon UPL, permissible maximum pressure, and design pressure.

(g) Designated maximum operating temperature.

(h) Serviceability criteria for inspection.

APPENDIX B. REFERENCES

Required References

1. FR/GE/UK/US ITOP 1-2-601, Laboratory Vibration Schedules, 19 October 1992.

2. FR/GE/UK/US ITOP 4-2-602, Rough Handling Tests, 23 October 1992.

3. NATO STANAG 2895 (Edition 1), Extreme Climatic Conditions and Derived Conditions for Use in Defining Design/Test Criteria for NATO Forces Material, 15 February 1990.

4. MIL-STD-810E, Environmental Test Methods and Engineering Guidelines, 14 July 1989; Notice 1, 9 February 1990.

5. US TOP 3-2-500, Weapon Characteristics, 9 November 1981.

6. US TOP 2-2-815, Rain and Freezing Rain, 19 June 1975.

7. GE/US ITOP 4-2-826, Solar Radiation Tests, 21 September 1983.

8. TECOM Pam 602-1, Volume 1, Questionnaire and Interview Design (Subjective Testing Techniques), 25 July 1975.

9. MIL-STD-1472D, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities, 14 March 1989.

10. TECOM Suppl 1 to AMC Reg 70-15, Integrated Logistic Support, 30 September 1991.

11. AR 385-16, System Safety Engineering and Management, 3 May 1990.

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a. Draft US TOP 4-2-504(3), Safety Testing of Mortar Ammunition, 31 October 1991.

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c. GE/US ITOP 3-2-810, Weapon Chamber Pressure Measurements, 18 December 1985.

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e. US MTP 3-2-801, Measurement of Internal Diameters of Cannon, 27 October 1965.

f. GE/US ITOP 3-2-803, Visual Inspection of Cannon Bores, 1 October 1992.

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